CHAPTER 4

Technical Design and Construction Methods

The wind retrofit projects described in this Guide are grouped into three possible Mitigation Package solutions: the Basic Mitigation Package (Section 4.1), the Intermediate Mitigation Package (Section 4.2), and the Advanced Mitigation Package (Section 4.3). Additional mitigation measures not included in the Mitigation Packages are discussed in Section 4.4. Each Mitigation Package consists of several wind retrofit mitigation measures to reduce future losses. The Packages should be implemented cumulatively, beginning with the Basic Mitigation Package. This means that for a home to successfully meet the criteria of the Advanced Mitigation Package, it must also meet the criteria of the Basic and Intermediate Mitigation Packages. Figure 4-1 illustrates the retrofits for each Package.

FIGURE 4-1:
Mitigation Packages for wind retrofit projects

The wind mitigation retrofits for each Package, if implemented correctly, will improve the performance of residential buildings when subjected to high winds. Although the information in this chapter will be helpful to homeowners, it is primarily intended for evaluators, contractors, and design professionals. The retrofits described for each Mitigation Package and throughout this chapter are not necessarily listed in the order in which they should be performed. The order in which retrofits should be performed depends on the configuration of the home and should be determined once the desired Mitigation Package is chosen. For example, a home that seeks the Advanced Mitigation Package should consider retrofitting the roof-to-wall connections when retrofitting the soffits (part of the Basic Mitigation Package). Therefore, the reader is encouraged to read this entire chapter and consider the most cost-effective way to implement the wind retrofit project before starting construction.

4.1 Basic Mitigation Package

The Basic Mitigation Package is the initial, most basic package for a residential wind retrofit project. It focuses on securing the roof system and improving the water intrusion resistance of the existing home.

The Basic Mitigation Package involves several steps:

1. Improving the roof system through one of two options:
   a) Option 1 – Improve roof with roof covering replacement
   b) Option 2 – Improve roof without roof covering replacement
2. Strengthening vents and soffits
3. Strengthening overhangs at gable end walls (if gable end walls exist on the home)
4. Protecting openings (if located within the windborne debris region)

BASIC MITIGATION PACKAGE RETROFITS:

Option 1 – Improvements with Roof Covering Replacement

- Securing the roof deck and replacing the roof covering
- Installing and improving secondary underlayments
- Improving roof coverings

Option 2 – Improvements without Roof Covering Replacement

- Securing roof deck attachment/providing secondary water barrier using foam adhesive

Additional Required Retrofits

- Strengthening vents and soffits
- Strengthening overhangs at gable end walls
- Window and entry door protection from windborne debris, garage door protection from wind pressure, and garage door glazing protection from windborne debris (if located within the windborne debris region)

One of the first decisions to make when implementing the Basic Mitigation Package is whether to use Option 1 or Option 2. The evaluation process will identify whether the roof covering needs to be replaced (see Section 3.1.1 for more information).

If the home is located in a windborne debris region, the opening protection measures of the Intermediate Mitigation Package (see Section 4.2.1) should be performed for the Basic Mitigation Package in addition to the other retrofits.

4.1.1 Option 1 – Improvements with Roof Covering Replacement

Option 1 of the Basic Mitigation Package involves removing the existing roof covering, securing the roof deck by adding roof deck-to-framing fasteners, installing an underlayment for protection against water infiltration, and installing a new roof covering. Option 1 is preferred over Option 2 because replacing the roof covering ensures that the roof deck connections to the framing below will be checked and an adequate underlayment will be installed. It should also be noted that homes retrofitted to Option 1 will likely receive a greater reduction in insurance premiums than homes retrofitted to Option 2.

4.1.1.1 Securing the Roof Deck and Replacing the Roof Covering

Strengthening the connections from the roof decking (sheathing) to the roof framing members is a cost-effective and beneficial retrofit to implement when the roof covering is being replaced. The evaluation process should identify any areas of the roof deck and roof framing members that are damaged or deteriorated (refer to Chapter 3 and Appendix B). Any damaged members should be repaired before the roof deck is secured with additional fasteners. Existing fastening of the roof deck to framing members should be augmented as required to meet criteria shown in Table 4-1 for wood board decking and Table 4-2 for structural wood panel sheathing. Nails that have full round head configurations should be used (8d ring-shank [0.113-in x 2-3/8-in] for structural wood panel sheathing and 8d common smooth-shank [0.131-in x 2-1/2-in] for wood board decking); clipped head nails should not be used. For structural wood panels, different fastener schedules are provided in Table 4-2 for inside the 4-foot roof edge zones and outside of these zones. Figure 4-3 illustrates the 4-foot edge zones for hip and gable roofs. When using Table 4-2, note that there are several assumptions (listed as end notes to the table) that limit the use of this table. If project conditions exceed the assumptions stated in the table endnotes, a different prescriptive solution or a designed solution should be used instead. Technical Fact Sheet No. 7.1 (see Figure 4-2) of FEMA 499, *Home Builder's Guide to Coastal Construction Technical Fact Sheet Series* (FEMA, 2010a), provides additional guidance on proper roof sheathing attachment.

Note: Dimensions of common nails used in this guide are specified in American Society for Testing and Materials (ASTM) F1667.

TABLE 4-1: Fasteners Required for Wood Board Decking Attachment to Framing

Nominal Board Thickness (inch)	Nominal Board Width (inch)	Minimum Number of Nails	Nail Minimum Diameter (inch)	Nail Minimum Penetration into Framing (inch)	Maximum Framing Member Spacing (inch)
Up to 1	Less than 8	2	0.131 (8d common)	1-5/8	24
	More than 8	3	0.131 (8d common)	1-5/8	24
1 to 2	Less than 8	2	0.162 (16d common)	1-5/8	24
	More than 8	3	0.162 (16d common)	1-5/8	24

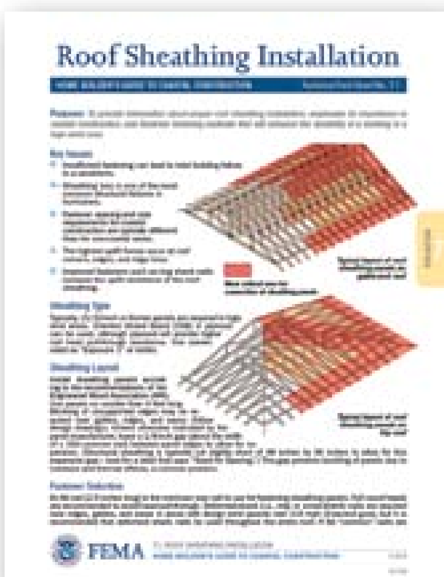


FIGURE 4-2:
FEMA 499 Technical Fact Sheet No. 7.1, *Roof Sheathing Installation*

TABLE 4-2: Fasteners Required for Structural Wood Panel Sheathing Attachment to Framing

ASCE 7 05 Design Wind Speed (mph)	ASCE 7 10 Design Wind Speed (mph)	Existing Fasteners	Existing Fastener Schedule	Required Additional Fastening Within 4 Foot Zone: 8d Ring Shank Nails (0.113 in x 2 3/8 in, Full Round Head)	Required Additional Fastening Outside 4 Foot Zone: 8d Ring Shank Nails (0.113 in x 2 3/8 in, Full Round Head)
≤120	≤155	Staples or 6d common nails (0.113-in x 2-in)	Any	6-inch on center (o.c.) spacing between added fasteners along panel edges and intermediate framing	6-inch o.c. spacing between added fasteners along panel edges and intermediate framing
		8d common smooth shank nails (0.131-in x 2-1/2-in)	≤ 6 inches o.c. along panel edges and intermediate framing	No additional fasteners required along panel edges; 6-inch o.c. spacing between additional fasteners along intermediate framing	No additional fasteners required
		8d common smooth shank nails (0.131-in x 2-1/2-in)	> 6 inches o.c.	6-inch o.c. spacing between existing and added fasteners along panel edges; 6-inch o.c. spacing between additional fasteners along intermediate framing	6-inch o.c. spacing between existing and additional fasteners along panel edges and intermediate framing
		8d ring shank nails (0.113-in x 2-3/8-in)	12 inches o.c. or less	6-inch o.c. spacing between existing and additional fasteners along panel edges and intermediate framing	6-inch o.c. spacing between existing and additional fasteners along panel edges and intermediate framing
>120 and ≤150	>155 and ≤194	Staples or 6d common nails (0.113-in x 2-in)	Any	4-inch o.c. spacing between added fasteners along panel edges and intermediate framing	6-inch o.c. spacing between added fasteners along panel edges and intermediate framing
		8d common smooth shank nails (0.131-in x 2-1/2-in)	< 6 inches o.c.	4-inch o.c. spacing between existing and added fasteners along panel edges; 6-inch o.c. between additional fasteners along intermediate framing	No additional fasteners required along panel edges; 6-inch o.c. spacing between added fasteners along intermediate framing
		8d common smooth shank nails (0.131-in x 2-1/2-in)	≥ 6 inches o.c.	4-inch o.c. spacing between existing and added fasteners along panel edges and intermediate framing	6-inch o.c. spacing between existing and added fasteners along panel edges; 6-inch o.c. spacing between added fasteners along intermediate framing
		8d ring shank nails (0.113-in x 2-3/8-in)	≤ 12 inches o.c.	4-inch o.c. spacing between existing and added fasteners along panel edges and intermediate framing	6-inch o.c. spacing between existing and added fasteners along panel edges and intermediate framing

Notes:

Minimum nominal 7/16 in. thickness wood structural panel sheathing.
Wind Exposure Category: Exposure C.
Mean roof height not to exceed 30 feet.
Roof framing specific gravity, G, not less than 0.55 (southern pine).
See Figure 4-3 for identification of 4-foot zone on roof.

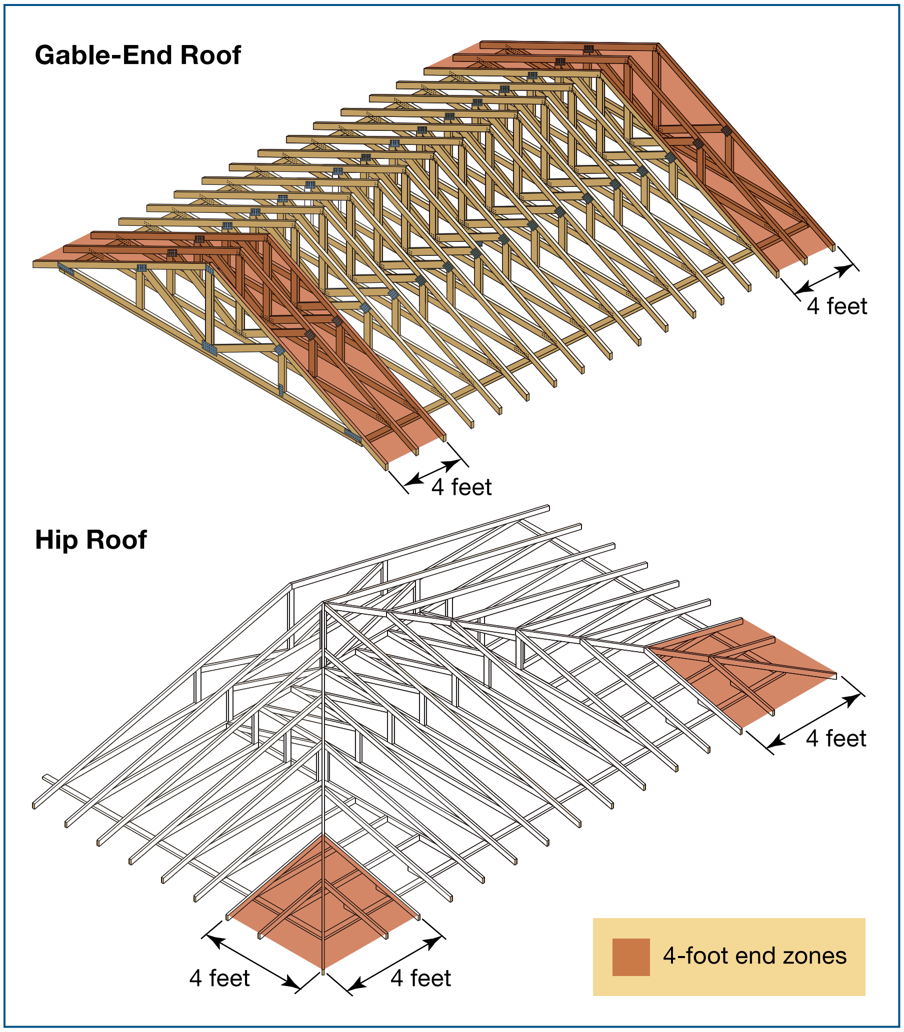


FIGURE 4-3: 4-foot end zones on gable and hip roofs

4.1.1.2 Installing Secondary Water Barriers

Under Option 1, a SWB should be installed after the roof deck connection to framing members has been sufficiently improved. Before installing the SWB, the roof deck should be broom-cleaned to ensure a smooth surface for the application of the SWB. If properly installed, a SWB provides an additional layer of water resistance to the roof system. SWBs for shingle, metal, clay, and tile roof coverings are discussed below. For other roof covering types, refer to FEMA 55.

Secondary Water Barriers for Roofs with Shingle or Metal Roof Coverings

This section provides guidance for installing SWBs over structural wood panel sheathing. The SWB should be applied after the roof deck has been adequately strengthened and before a new roof covering is installed. FEMA 499 Technical Fact Sheet No. 7.2 (see Figure 4-4) provides guidance on the installation process that should be followed when installing SWBs beneath asphalt shingle roof coverings. Although not specifically addressed, Technical Fact Sheet No. 7.2 can also provide guidance on installing SWBs over wood board decking.

One of the following underlayment alternatives for roofs with shingle or metal coverings should be selected (note that Alternative 3 is only applicable in areas with a design wind speed less than or equal to 110 mph).

Shingle or Metal Roof Alternative 1

1. The entire roof deck should be covered with a full layer of self-adhering, modified bitumen membrane meeting the criteria described in ASTM D1970.
2. To prevent the roof covering from bonding with the membrane (which can lead to damage of the sheathing when the roof covering is replaced later), the membrane should be covered with a bond break underlayment meeting ASTM D226 Type I (#15).
3. The underlayment should be fastened to the roof to sufficiently hold it in place until installment of the shingles can affix the underlayment to the roof deck.

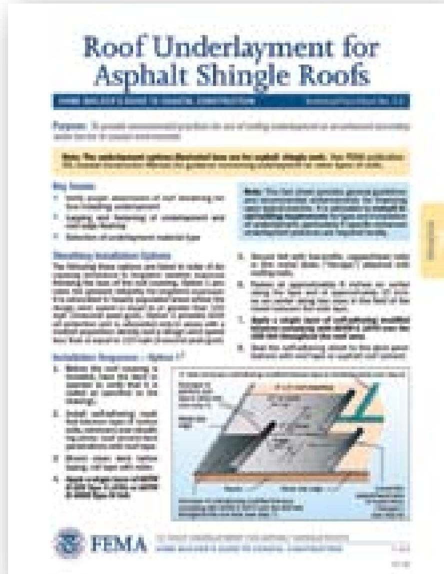


FIGURE 4-4:
FEMA 499 Technical Fact Sheet No. 7.2, *Roof Underlayment for Asphalt Shingle Roofs*

Shingle or Metal Roof Alternative 2

1. A self-adhering modified bitumen flashing tape at least 4 inches wide should be applied directly to the roof deck along the horizontal and vertical joints in the roof sheathing. Do not nail or staple the tape to the roof sheathing. Refer to manufacturer's recommendations for installation instructions.
2. Two layers of an underlayment meeting ASTM D226 Type II (#30) should be installed over the self-adhering tape. The underlayment should be attached using annular ring or deformed shank roofing fasteners with a minimum of 1-inch-diameter caps at 6-inch o.c. spacing along all laps and at 12 inches o.c. in the field (or a more stringent fastener schedule if required by the manufacturer for high-wind installations). Horizontal laps should be a minimum of 2 inches, and end laps should be a minimum of 6 inches. Nails with plastic or metal caps should be used where the design wind speed is less than 140 mph. For areas where the design wind speed is greater than or equal to 140 mph, metal caps should be used rather than plastic caps.
3. A self-adhering polymer modified bitumen membrane complying with ASTM D1970 should be installed over this underlayment for areas where the design wind speed is equal to or greater than 120 mph.

Note: When applying a self-adhering membrane directly to oriented strand board (OSB), the adhesiveness of the membrane may be reduced depending on surface texture, amount of wax on the sheathing panel, and job site conditions. In such cases, a primer should be applied to the OSB panels to improve adhesion between membrane and sheathing.

Shingle or Metal Roof Alternative 3 (for design wind speeds of 110 mph or less)

1. A self-adhering modified bitumen flashing tape at least 4 inches wide should be applied directly to the roof deck along horizontal and vertical joints.

2. A single layer of ASTM D226 Type I (#15) or ASTM D4869 Type II felt should be installed over the self-adhering tape. The underlayment should be held in place using tacks before shingles are applied.

Secondary Underlayments for Concrete and Clay Tile Roofs

For concrete and clay tile roofs, one of the following underlayment alternatives should be followed.

Tile Roof Alternative 1

1. The entire roof deck should be covered with a full layer of self-adhering polymer modified bitumen membrane meeting ASTM D1970. Note that some local building departments, such as Miami-Dade and Broward Counties in Florida, prohibit the use of this system. The local building department should be consulted before implementing this alternative.

Tile Roof Alternative 2

1. Self-adhering modified bitumen flashing tape at least 4 inches wide should be applied directly to the roof deck along horizontal and vertical joints in the roof sheathing. Do not nail or staple the tape to the roof sheathing. Refer to the underlayment manufacturer's recommendations for installation instructions.

2. An underlayment meeting ASTM D226 Type II (#30) should be installed over the self-adhering tape. The underlayment should be attached using annular ring or deformed shank roofing fasteners with a minimum of 1-inch-diameter caps at 6-inch o.c. spacing along all laps and at 12 inches o.c. in the field (or a more stringent fastener schedule if required by the manufacturer for high-wind installations). Horizontal laps should be a minimum of 2 inches, and end laps should be a minimum of 6 inches. Nails with plastic or metal caps should be used only where the design wind speed is less than 140 mph. Only metal caps should be used for areas where the design wind speed is greater than or equal to 140 mph.

3. A self-adhering polymer modified bitumen membrane complying with ASTM D1970 should be installed over this underlayment.

Tile Roof Alternative 3

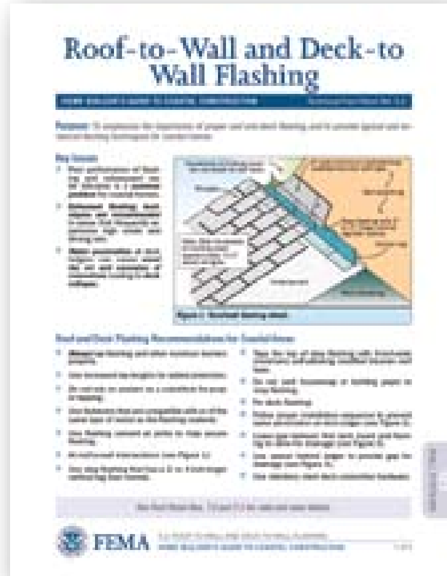
1. A self-adhering modified bitumen flashing tape at least 4 inches wide should be applied directly to the roof deck along horizontal and vertical joints in the roof sheathing.

2. An underlayment meeting ASTM D226 Type II (#30) should be installed over the self-adhering tape. The underlayment should be attached using annular ring or deformed shank roofing fasteners with a minimum of 1-inch-diameter caps at 6-inch o.c. spacing along all laps and at 12 inches o.c. in the field (or a more stringent fastener schedule if required by the manufacturer for high-wind installations). Horizontal laps should be a minimum of 2 inches and end laps should be a minimum of 6 inches. Nails with plastic or metal caps should be used only where the design wind speed is less than 140 mph. Only metal caps should be used in areas where the design wind speed is greater than or equal to 140 mph.

3. The underlayment should be hot mopped using hot asphalt, with a #90 mineral surface cap sheet applied over the hot asphalt.

Drip Edge and Flashing

When replacing roof coverings, a drip edge should be installed at eaves and gables. Guidance can be found in FEMA 499 Technical Fact Sheet No. 5.2 (see Figure 4-5) and in FEMA 55.


Roof-to-Wall and Deck-to Wall Flashing

FEMA

FIGURE 4-5: FEMA 499 Technical Fact Sheet No. 5.2, *Roof-to-Wall and Deck-to-Wall Flashing*

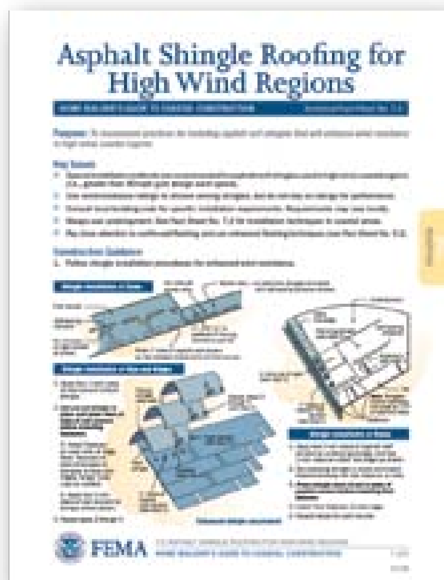
4.1.1.3 Installing a New Roof Covering

Historically, damage to roof coverings is one of the leading causes of building performance problems in high-wind events. The failure of roof covering on a home can lead to substantial water damage to interior finishes and contents. The existing roof covering should be removed entirely; the new roof covering should not be installed over an existing roof covering. The new roof covering should be rated for the design wind speed for the project location and should be installed in accordance with the manufacturer's recommendations for high-wind regions. Various roof covering types are readily available; this Guide provides information on replacing asphalt shingles, clay and concrete tiles, and metal panels with prescriptive retrofitting solutions for projects that involve replacing the roof covering. FEMA 499 Technical Fact Sheets and FEMA 55 provide guidance on roof covering material types.

> **Note:** When applying a new roof covering, the benefits of installing a reflective roof covering should be considered. Reflective roofs can reduce a building's heat gain, enhance the life expectancy of the roof, and provide energy savings to the homeowner. For more information, go to www.energystar.gov.

Asphalt Shingles

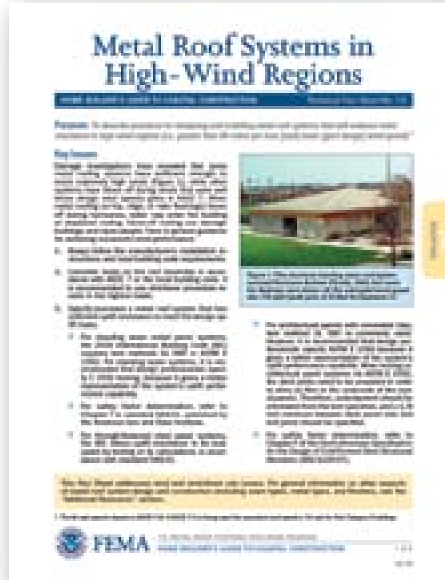
Two of the most common causes for damage to asphalt shingle roof coverings in high-wind events are improper installation and use of shingles that are not rated for the wind speeds identified in the building code and improper installation. It is important to understand the wind-resistance ratings and special installation methods for asphalt shingles used in high-wind, coastal regions.


Asphalt Shingle Roofing for High Wind Regions

FEMA

FIGURE 4-6: FEMA 499 Technical Fact Sheet No. 7.3, *Asphalt Shingle Roofing for High Wind Regions*

Asphalt shingles should be installed on homes in accordance with the criteria discussed in FEMA 499 Technical Fact Sheet No. 7.3 (see Figure 4-6), which explains asphalt shingle installation, wind-resistance ratings, and weathering and durability. Durability ratings (indicated by warranty life) are relative and not standardized; although shingles with a longer warranty (e.g., 30-year instead of 20-year) will probably have greater durability in coastal climates, the durability rating is not an indicator of the shingle's ability to resist a particular wind speed. The warranty for a shingle product indicates the ability of the product to resist deterioration from climate conditions. The warranty is an important characteristic to consider when selecting a shingle product, but it does not signify wind resistance. A shingle product that has a class rating equal to or greater than the design wind speed (for the location as specified in the building code) should be selected. For more information on wind-resistance ratings of asphalt shingles, see Technical Fact Sheet No. 7.3.



Metal Roof Systems in High-Wind Regions

FEMA

FIGURE 4-7:
FEMA 499 Technical Fact Sheet No. 7.6, *Metal Roof Systems in High-Wind Regions*

Metal Roof Systems

A variety of metal panel systems and metal shingles are available for both low- and steep-slope roofs. MAT investigations have found that some metal roofing systems have sufficient strength to resist high winds, while others have failed from wind speeds that were below design requirements. If installing a metal roof system, FEMA 499 Technical Fact Sheet No. 7.6 (see Figure 4-7) provides guidance on selecting and installing panel or shingle system.

Clay and Concrete Tiles

Clay and extruded concrete roof tiles are available in a variety of profiles and attachment methods. MAT investigations have found that tile coverings applied using foam- and mechanical-set attachment methods have historically performed better than applied using the mortar-set attachment method. Therefore, tile roof coverings in high-wind areas should not be installed using the mortar-set attachment method should not be used to install tile roof coverings in high-wind areas. However, all methods are prone to failure when not properly installed. Uplift loads and resistance should meet the requirements of the design wind speed and exposure category for the project location. FEMA 499 Technical Fact Sheet No. 7.4 provides guidance for the installation of tile roof coverings (Figure 4-8).

Tile Roofing for High Wind Regions

FEMA

FIGURE 4-8:
FEMA 499 Technical Fact Sheet No. 7.4, *Tile Roofing for High Wind Regions*

All Other Roof Coverings

Roof coverings other than those specified above may be used. If HMA grant funds are being sought, appropriate documentation from the manufacturer should be included with the project subapplication for the product so it can be reviewed; the documentation should include installation instructions for high-wind regions. When using other roof coverings, documentation showing that the roof covering and attachments were designed for the component, cladding wind pressures for the appropriate design wind speed (of up to 150 mph), and exposure category should be provided. All roof coverings, regardless of type, should be installed in accordance with the manufacturer's installation instructions for the appropriate design wind speed.

4.1.2 Option 2 – Improvements without Roof Covering Replacement

Option 2 of the Basic Mitigation Package is recommended when the existing roof covering is not replaced as part of the wind retrofit project. Option 2 involves applying spray polyurethane foam (SPF) adhesive to the underside of the roof deck at the joints between roof sheathing panels and along all intersections between the roof deck and framing members as shown in Figure 4-9. This retrofit serves two purposes:

1. The connection between the roof deck and supporting structural members is enhanced, which increases the ability of the roof deck to resist uplift during high-wind events.
2. The SPF adhesive seals the joints of the roof deck to help prevent water intrusion. While not as effective as installing an underlayment, the SPF adhesive will help minimize water infiltration.

The SPF product selected should be one that has been successfully tested in accordance with Testing Application Standard (TAS) 202-94, *Criteria for Testing Impact and Non-Impact Resistant Building Envelope Components Using Uniform Static Air Pressure* (ICC, 1994); design uplift pressure for the SPF should be

FIGURE 4-9: Example of SPF adhesive application to secure roof deck panels

equal to or greater than 110 pounds per square foot (psf). The product should also be a two-component SPF system that complies with ASTM D1622, *Standard Test Method for Apparent Density of Rigid Cellular Plastics*. FEMA 499 Technical Fact Sheet No. 9.2 (Figure 4-10) cites an additional reference, *Not Ready to Re-Roof? Use Structural Adhesive to Strengthen the Attachment of Roof Sheathing* (S.C. Sea Grant Extension Program 2001), which provides guidance on securing roof deck connections using spray foam adhesive.


Repairs, Remodeling, Additions, and Retrofitting–Wind

FEMA

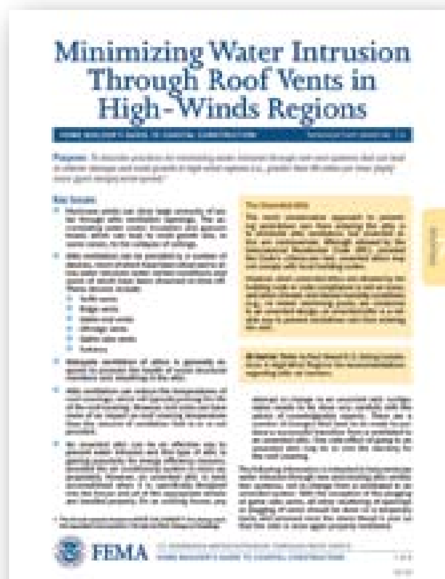
FIGURE 4-10:
FEMA 499 Technical Fact Sheet No. 9.2, *Repairs, Remodeling, Additions, and Retrofitting—Wind*

4.1.3 Strengthening Vents and Soffits

Much of the damaged caused by past high-wind events has been due to attic ventilation openings that are not capable of resisting failure from high-wind forces. These vulnerable components should be retrofitted as part of the Basic Mitigation Package, regardless of whether Option 1 or Option 2 is chosen. Attic ventilation openings include the following:

- Soffit vents
- Ridge vents
- Off-ridge vents
- Gable rake vents
- Turbines

FEMA 499 Technical Fact Sheet No. 7.5 (see Figure 4-11) provides retrofit criteria for each type of attic ventilation opening. Work on soffits in particular provides an excellent opportunity to retrofit the roof-to-wall connections, which is one of the Advanced Mitigation Package retrofits. Strengthening the roof-to-wall connections will maximize the engagement of the existing uplift resistance in the walls and connections to the foundation; though this is not required under the Basic Mitigation Package, it is an important retrofit and can often be accomplished cost effectively while doing work on soffits as part of the Basic Mitigation Package.


Minimizing Water Intrusion Through Roof Vents in High-Winds Regions

FEMA

FIGURE 4-11:
FEMA 499 Technical Fact Sheet No. 7.5, *Minimizing Water Intrusion through Roof Vents in High-Wind Regions*

Note: Number 8 wood screws specified in this Guide should comply with ANSI/ASME (American Society of Mechanical Engineers) B18.6.1 and be 0.164 inch in diameter (or equivalent).

Depending on the condition of existing soffits (determined during the evaluation process described in Chapter 3 and Appendix B), the soffit panels should be either removed and reinstalled or replaced with new material. The most critical soffit installations are

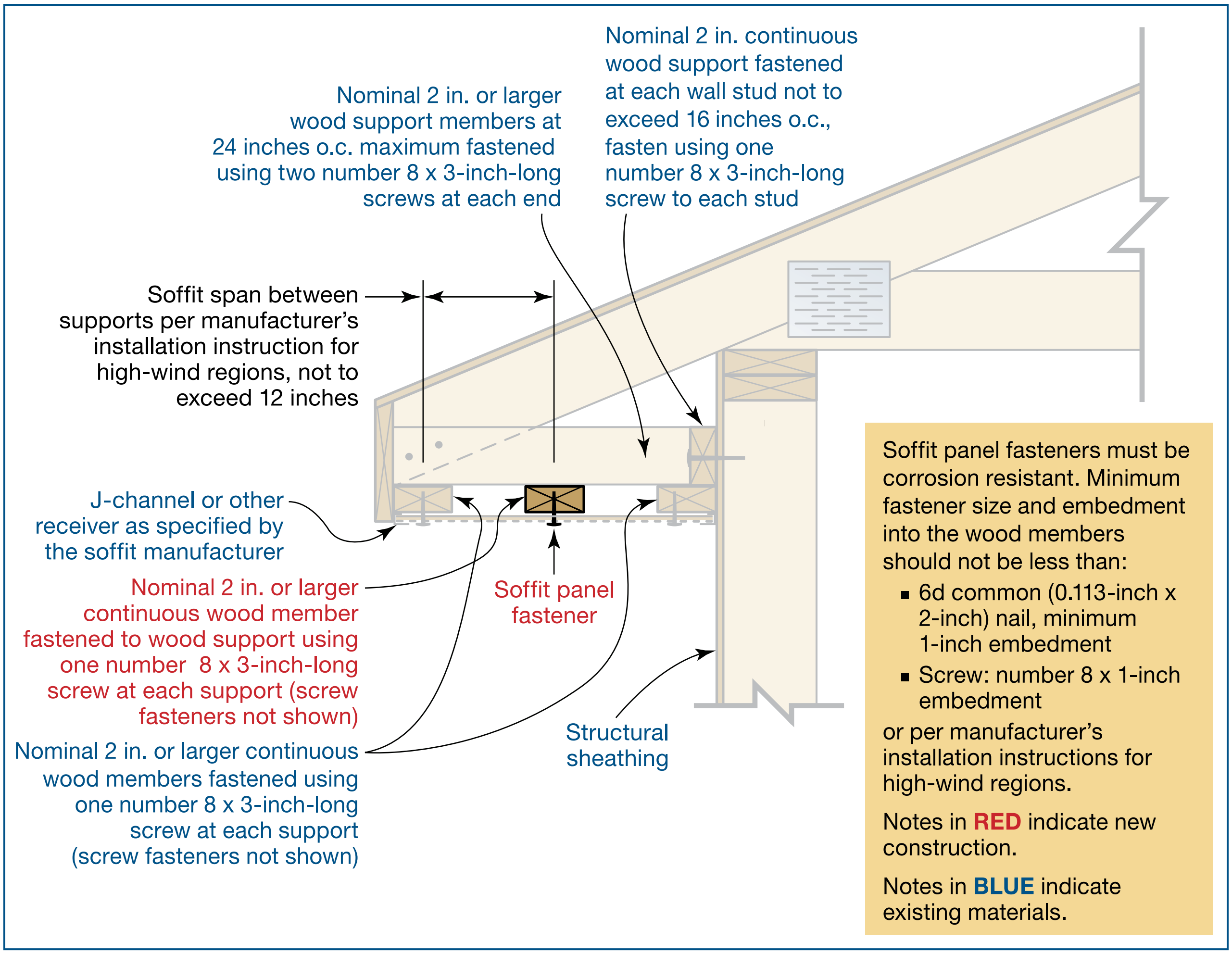


FIGURE 4-12:
Typical soffit retrofit using wood supports

those with vinyl or aluminum soffit panels. Aluminum soffit panels can also be vulnerable because of aluminum's corrosion potential in a salt environment. If the house is within 3,000 feet of saltwater, aluminum soffits should be removed completely, and a new soffit system installed according to the guidance of Technical Fact Sheet No. 7.5. Figure 4-12 shows a typical detail for retrofitting soffits. It should be noted that although many homes have different soffit configurations from the one depicted here, the intent of the retrofit as shown in Figure 4-12 (to provide continuous edge support and appropriate intermediate support for the soffit) should be carried out by the applied retrofit project. Additionally, the selected soffit products may have more restrictive installation instructions when installed in high-wind regions, in which case the more restrictive installation method should be used. Soffits should also be secured using sealant and screws as described in Technical Fact Sheet No. 7.5.

4.1.4 Strengthening Overhangs at Gable End Walls

Gable end walls are particularly vulnerable to damage in high-wind events due to their structural configuration. Loads created by high winds can quickly overwhelm the capacity of gable end walls that do not have adequate structural connections. Ensuring that there are adequate connections between gable end walls and roof framing is an important component of a wind retrofit project. If a home undergoing a wind retrofit project has gable end walls, they should be retrofitted as described in this section.

FEMA 55 has detailed design guidance on the connections for gable end walls, including bracing recommendations. To be applicable for these prescriptive retrofit criteria, the overhangs should be at least nominal 2x4 members spaced no greater than 24 inches o.c. The overhangs and gable end wall framing or truss framing should not be notched.

To retrofit the overhangs at gable ends, a saddle type hurricane clip should be added to connect the overhang to the gable end wall/truss (see Figure 4-13). A joist hanger should also be added to secure the overhang member to the roof framing member. Figure 4-13 shows a conceptual retrofit that may not be applicable for different configurations. Although configurations may vary, it is important that the intent of the retrofit as described in Figure 4-13 be accomplished. This retrofit should be completed *before* the roof sheathing is strengthened, regardless of whether that is implemented by re-nailing the roof sheathing or applying an SPF adhesive to the underside of the sheathing (see Sections 4.1.1 and 4.1.2). When retrofitting soffits, accessing the overhang and gable end connections may be easier (see Section 4.1.3).

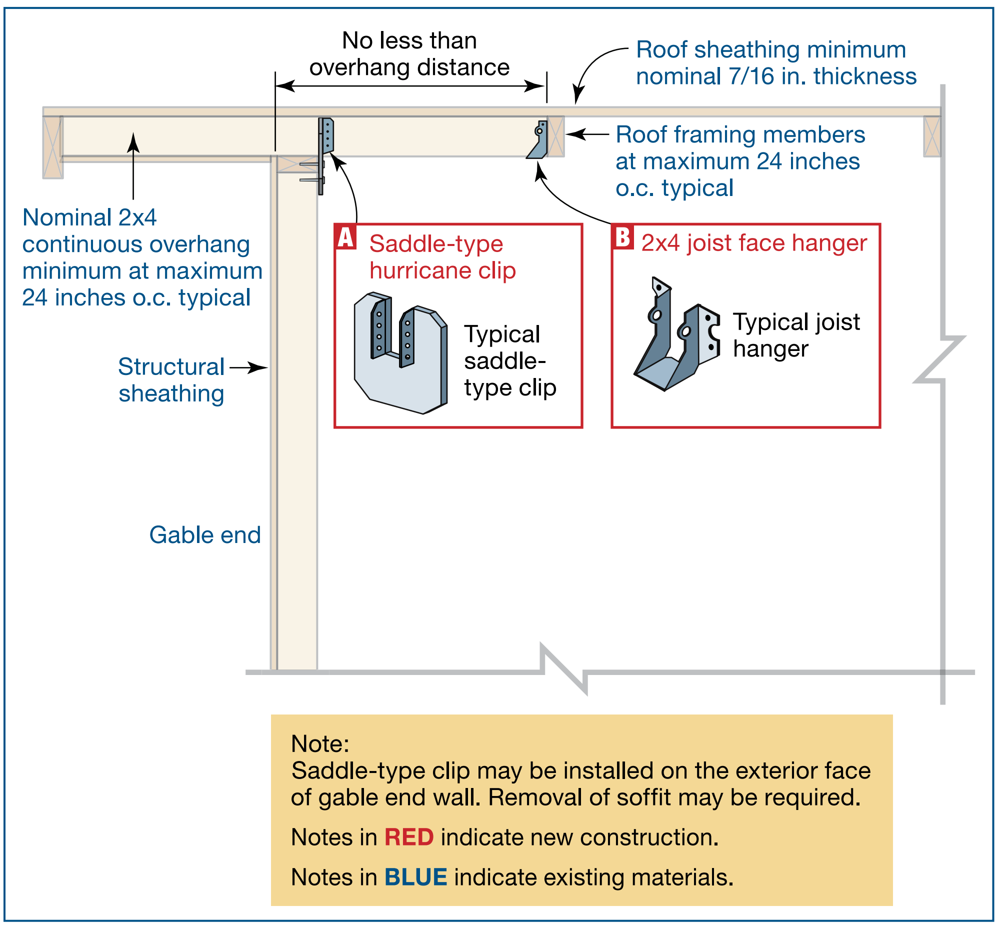


FIGURE 4-13:
Bracing gable end overhangs

4.2 Intermediate Mitigation Package

The Intermediate Mitigation Package is the second level of high-wind mitigation described in this Guide. For this package to be effective, the mitigation measures identified for the Basic Mitigation Package must first be successfully completed. The Intermediate Mitigation Package includes retrofits to protect openings, further strengthen gable ends that are over 4 feet in height (if applicable), and improve the anchorage of attached structures such as porches and carports.

INTERMEDIATE MITIGATION PACKAGE RETROFITS:

- Window and entry door protection from windborne debris, garage door protection from wind pressure, and garage door glazing protection from windborne debris
- Bracing gable end walls over 4 feet tall
- Strengthening connections of attached structures

4.2.1 Protecting Openings

Building openings include windows, skylights, entry doors, and garage doors. If these components fail, wind-driven rain can enter the building and cause costly water damage. In addition, the increase in internal wind pressure is likely to increase the chance for a structural failure. Opening protection can be provided by one of two methods for the Intermediate Mitigation Package:

- An approved impact-resistant covering capable of resisting windborne debris impacts can be installed over an existing, unprotected opening (such as a window or door). Types of impact-resistant coverings include shutter systems and fabric and screen products.
- An approved, impact-resistant product (such as a new window or door assembly) can be installed in place of a product that is not designed to resist such forces or as an alternative to impact-resistant shutters or screens. However, these are systems or "assemblies," and protecting only the glass (or glazing) is not adequate. A tested and approved system that includes the frame and the glazing system must be used.

Note that shutters, screens, and other panel systems that protect glazing from debris impacts are often not rated to reduce wind pressures on the opening they protect. A system that has a pressure rating has typically been rated for resistance to that pressure for avoiding blow-off or excessive deflection, not for decreasing pressure on the window or door that the system protects. While this is not true for all impact-resistant covering products, product specifications and test criteria should be scrutinized carefully in the planning process of a wind retrofit project. More information on opening protection can be found in Chapter 10 of FEMA P-762, *Local Officials Guide for Coastal Construction* (FEMA, 2009b).

Note: For homes located in a windborne debris region, the windows, entry doors, and garage doors need to be protected, even if only the Basic Mitigation Package is being implemented. The opening protection retrofits to implement for windows, entry doors, and garage doors in windborne debris regions are presented under the Intermediate Mitigation Package described in this section.

Opening protection guidance provided in this Guide is primarily focused on identifying the test criteria to which an approved product should be certified, as well as general guidance on selecting the type of protection. For further guidance on protecting openings, see FEMA 499 Technical Fact Sheet No. 6.2 (Figure 4-14). FEMA 499 Technical Fact Sheet No. 6.1 also provides guidance on proper installation of windows and doors.

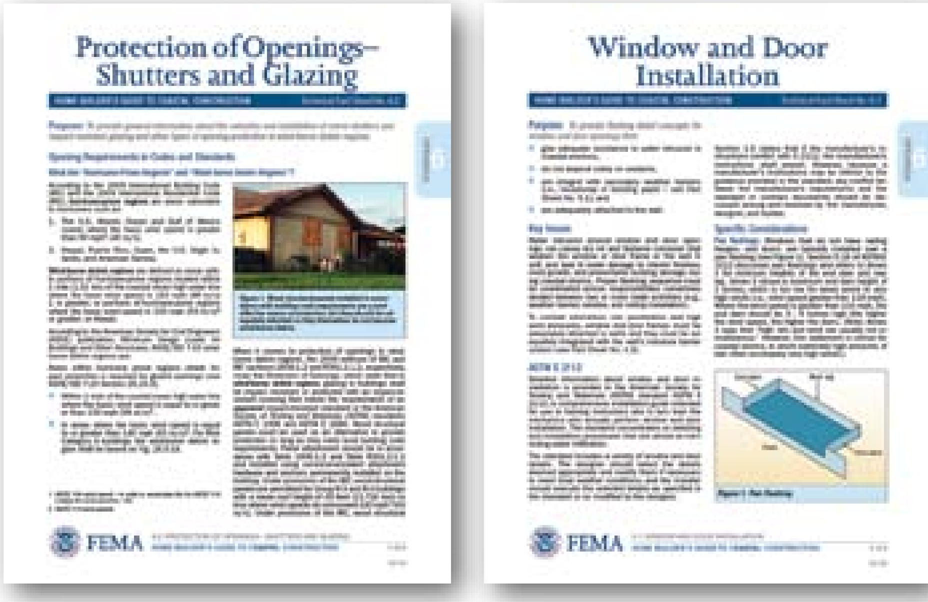


FIGURE 4-14:
FEMA 499 Technical Fact Sheets No. 6.2, *Protection of Openings—Shutters and Glazing,* and No. 6.1, *Window and Door Installation*

4.2.1.1 Windows

Windows can be retrofitted using either of the previously described opening protection methods for the Intermediate Mitigation Package. Though installing an impact-resistant window is typically more expensive than installing an impact-resistant covering, it is also a more complete method of protecting the window. This is because impact-resistant coverings, such as shutter systems, do not typically cover openings at all times. Shutter systems must be set in place before the wind event occurs to be effective. This can be problematic if no one is present to install or operate the shutter system or, if operated electronically, if the power fails before someone has a chance to close them. Before a particular product is chosen, it should be confirmed that it has been certified to the appropriate standards.

Impact-resistant covering products should be tested to demonstrate compliance with ASTM E1996 in accordance with the procedures defined in ASTM E1886. Testing includes both missile impact testing and cyclical pressure differential testing. Products certified to resist the "D Missile" defined in ASTM E1996 are recommended (a 9-pound [lb], 8-foot-long, 2x4 board member traveling horizontally at 34 mph).

The manufacturer's instructions for the appropriate design wind speed should be followed when installing any form of opening protection. FEMA 499 Technical Fact Sheet No. 6.1 provides

SKYLIGHTS

Due to their varying configurations, approved impact-resistant coverings (such as shutters) for skylights are not readily available. If a home has skylights, the solutions to meet the level of protection offered by the Intermediate Mitigation Package are:

- Replace the existing skylights with an approved, impact-resistant skylight (if available)
- Remove the skylight and secure the opening (this may require a design professional)

guidance on proper installation of windows. Documentation of the certified level of protection for the product should be readily available. The 2009 IBC and IRC both require labeling on exterior windows; Section R612.6 of the 2009 IRC requires exterior windows to be labeled in conformance with *Standard/Specification for Windows, Doors, and Unit Skylights* (AAMA, 2007), a standard that prescribes labeling requirements for windows, doors, and unit skylights. While some jurisdictions may not have adopted this requirement, labeling of products such as windows, doors, and shutter systems showing the level of protection to which the product has been certified should be readily available.

Shutter systems are the most common form of impact-resistant covering products, and are either temporarily or permanently installed. Temporary shutters are lower in cost compared to permanent shutters, but require ongoing effort on the part of the homeowner to use them effectively for opening protection.

USING FILMS FOR OPENING PROTECTION

Opening protection products such as films and other overlays are not appropriate methods of opening protection for a wind retrofit project. An overlay on glazing does not provide certified protection for the opening unless the whole assembly—including the glazing, opening frame, and overlay product—are tested together and certified to the appropriate test criteria.

Temporarily Installed Shutters

Though lower in cost than permanent shutters, temporary shutters must be installed and removed every time they are needed, and require storage space when not in use. Installation of temporary shutters before a storm is often left to the homeowner, and can be difficult on upper level windows of homes that are two or more stories high. For this reason, it is recommended that windows above the ground floor be protected by a permanent shutter system or that existing windows be replaced with impact-resistant windows.

One form of commonly used temporary shutters is wood structural panels. While wood structural panels are inexpensive, they tend to have shorter useful life spans and require storage conditions where the wood will not become warped, which causes rapid installation to be difficult. Wood structural panel shutters are typically comprised of a variety of combinations of panels, fasteners, and anchoring hardware. Detailed installation instructions, storage, handling, and maintenance procedures for specific combinations of materials needed for the shutter system to perform as expected are generally not available. Further, a standard "missile" will breach the code-prescribed wood structural panel shutter, and the desired level of protection is no breaching of the shutter. Because they may not provide the desired level of protection, wood structural panel shutters are not eligible for inclusion in an HMA grant application. However, if wood structural panels are the only affordable solution to protect the windows of a home, they may be considered outside of an HMA grant application. More information on using wood structural panels as shutters can be found at www.apawood.org/level_b.cfm?content=app_bas_wind.

Permanently Installed Shutters

Shutter systems that are permanently installed are more expensive than temporary shutters, but they are always in place and ready to be closed. Permanent shutter systems are operated either manually or by a motor. Manually operated shutters are less expensive than motorized shutters, but are closed from the outside. Motorized shutters are easily closed from the interior, but are among the most expensive type of shutter system. Motorized shutters should also be able to be operated manually in the event of loss of power. If a shutter system is used to protect windows, it should be sufficiently anchored into the wall around the window frame so that wind loads are transferred to the structure of the building.

If impact-resistant windows are the desired form of window protection, the existing window assemblies should be removed and replaced with new assemblies that meet the appropriate criteria. Similar to impact-resistant coverings, impact-resistant windows should be tested to demonstrate compliance with ASTM E1996 (using the "D Missile") in accordance with the procedures defined in ASTM E1886. Additionally, the selected window product should be tested to demonstrate compliance with ASTM E1233 (a cyclical air pressure differential test).

4.2.1.2 Entry Doors

As part of the Intermediate Mitigation Package, all exterior entry doors should be protected from windborne debris and design wind pressure; at least one entry door should be operable from inside the living space if opening protection is in place. Entry doors should be protected by either protecting the existing door with an impact-resistant covering or providing an impact-resistant door. Regardless of whether the chosen product is an impact-resistant covering or an impact-resistant door, it should be tested to demonstrate compliance with ASTM E1996 (using the "D Missile") in accordance with the procedures defined in ASTM E1886. An impact-resistant door should also be tested to demonstrate compliance with ASTM E1233.

4.2.1.3 Garage Doors

Garage doors are typically large, unreinforced openings that are commonly damaged during high-wind events. As part of the Intermediate Package, any garage doors on a home should be capable of resisting design wind pressure. For garage doors with glazing that is less than 1 square foot (for one-car garages) or 1.8 square feet (for two-car garages), the garage door may be retrofitted to resist design wind pressures through one of two methods:

- Install a garage door that is certified to resist the design wind pressure for the location.
- Protect the existing garage door by installing an impact-resistant covering that protects the entire door and is certified to resist the design wind pressure for the location.

If a garage door has glazing that is greater than 1 square foot (for one-car garages) or 1.8 square feet (for two-car garages), it should be certified to resist both windborne debris impacts and the design wind pressure for the location. This can be achieved through one of two retrofits:

- Install a garage door that is certified to resist both missile impacts and the design wind pressure for the location.
- Protect the existing garage door by installing an impact-resistant covering that protects the entire door and is certified to resist the design wind pressure for the location.

Acceptable test standards for design pressure resistance of garage door products include American National Standards Institute (ANSI)/Door and Access Systems Manufacturers Association (DASMA) 108 and ASTM E330. For the impact resistance of glazing, the product should be tested to demonstrate compliance with ANSI/DASMA 115. Section R612.7 of the 2009 IRC requires that garage doors be tested in accordance with either ASTM E330 or ANSI/DASMA 108; however, these standards do not establish test pressures, and therefore certification data must be closely examined to determine if the labeled product is appropriate for the design wind pressures. Also, while some manufacturers provide wind speed and exposure ratings for their products, labels on many garage doors do not include wind speed or wind pressure ratings. While not required to be included on the product labeling, ANSI/DASMA 108 does require that the positive and negative pressure used in testing be recorded on the ANSI/DASMA 108 Test Report Form. The standard also requires that the model number, description, and operating hardware be documented. Where wind speed or wind pressures are not specifically provided for the product, the Test Report Form documents that the garage door assembly has been tested to resist the appropriate design wind pressures.

4.2.2 Bracing Gable End Walls Over 4 Feet Tall

If gable ends on the home are 4 feet (or more) tall, they should be retrofitted as part of the Intermediate Mitigation Package. This retrofit builds upon the Basic Mitigation Package item for strengthening overhangs at gable end walls (see Section 4.1.4).

One method to retrofit gable end walls for the Intermediate Mitigation Package involves:

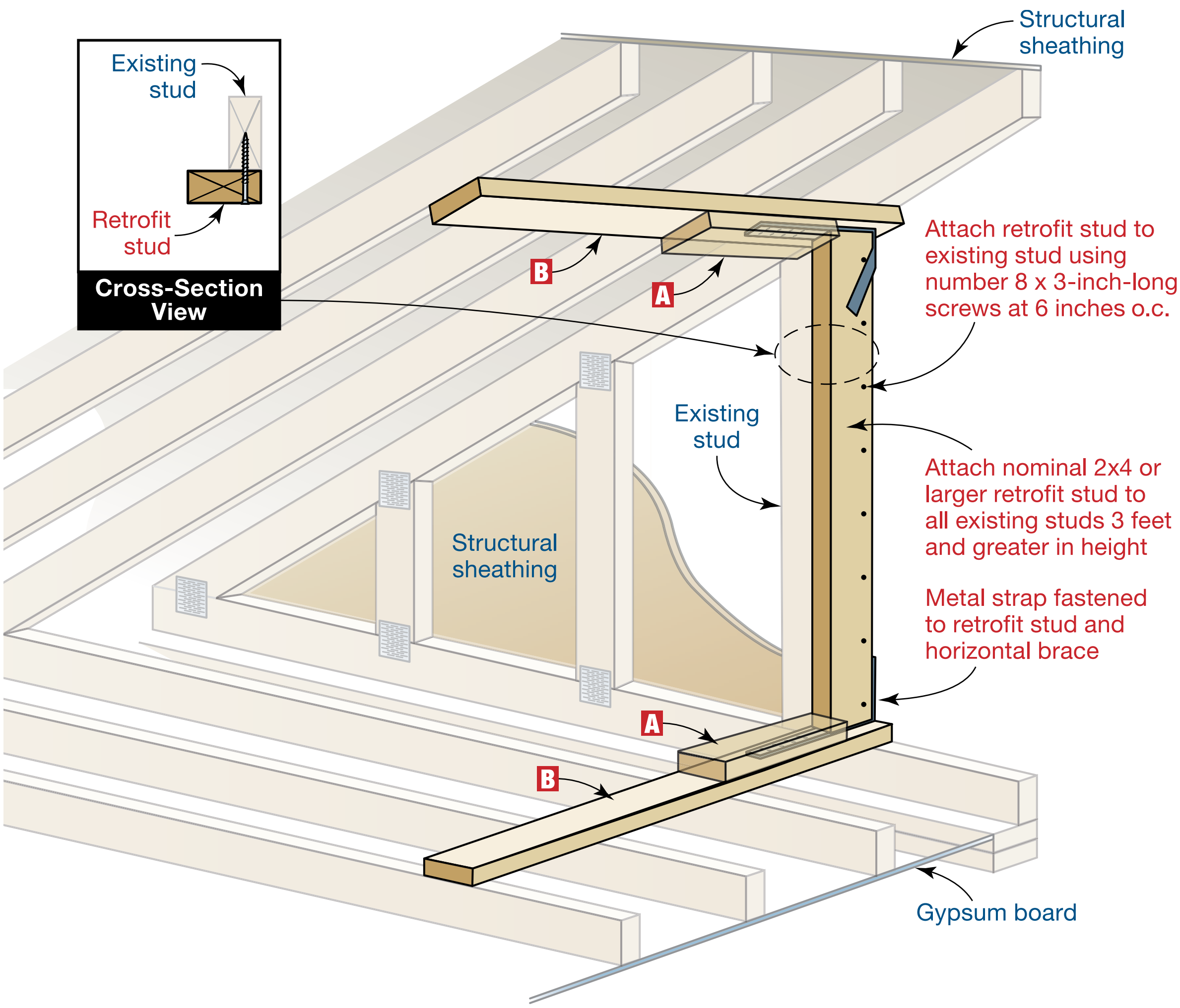
1. Strengthening vertical framing members of the gable end using retrofit studs.
2. Bracing the top and bottom of the gable end with horizontal braces to allow lateral loads to transfer to the roof and ceiling diaphragms.
3. Making connections between horizontal braces and retrofit studs using metal straps and fasteners.
4. Connecting the bottom of the gable end to the wall below using metal bracket connectors.

A conceptual detail showing these measures is provided in Figure 4-15 for a gable end wall without an overhang and in Figure 4-16 for a gable end wall with an overhang. Prescriptive solutions to address this retrofit can be used or a professional engineer may be needed to provide specific solutions in cases where prescriptive solutions are not applicable. The IEBC 2012 and the FEH program both contain prescriptive solutions that can be used to perform this retrofit. Although configurations may vary, it is important that the intent of the retrofit as shown in Figures 4-15 and 4-16 be accomplished.

4.2.3 Strengthening Connections of Attached Structures

For the purpose of this Guide, “attached structures” are connected to the home (and the main wind force resisting system of the home) and have a roof. Examples may include porches and carports. Attached structures can be significant hazards to a home during high-wind events if there is insufficient capacity to resist forces. Attached structures are typically supported by horizontal beam members connected to vertical columns, which are in turn connected to the foundation. If the structure has this typical configuration, the connections should be retrofitted by adding metal connectors that meet or exceed loads and installed according to manufacturer’s recommendations. These measures will strengthen the load path for the attached structure to transfer applied wind loads to the foundation. The connectors should be added to the following areas of the attached structure:

Between supporting roof members and horizontal beams. Wood-to-wood connections should be strengthened using a saddle-type hurricane clip. If the uplift load required is less than 800 lbs, the clip may be installed on either side of the beam. If the uplift load required is greater than 800 lbs, the clip should be installed on both sides of the beam.



A Nominal 2x4 compression block bearing tight to retrofit stud and fastened to horizontal bracing member with number 8 x 3-inch-long screws. Fasteners between compression block and horizontal brace must not go through the metal strap

B Nominal 2x4 horizontal bracing member fastened to framing at each crossing with three number 8 x 3-inch-long screws

Notes in **RED** indicate new construction.

Notes in **BLUE** indicate existing materials.

FIGURE 4-15:
Conceptual gable end retrofit without overhangs

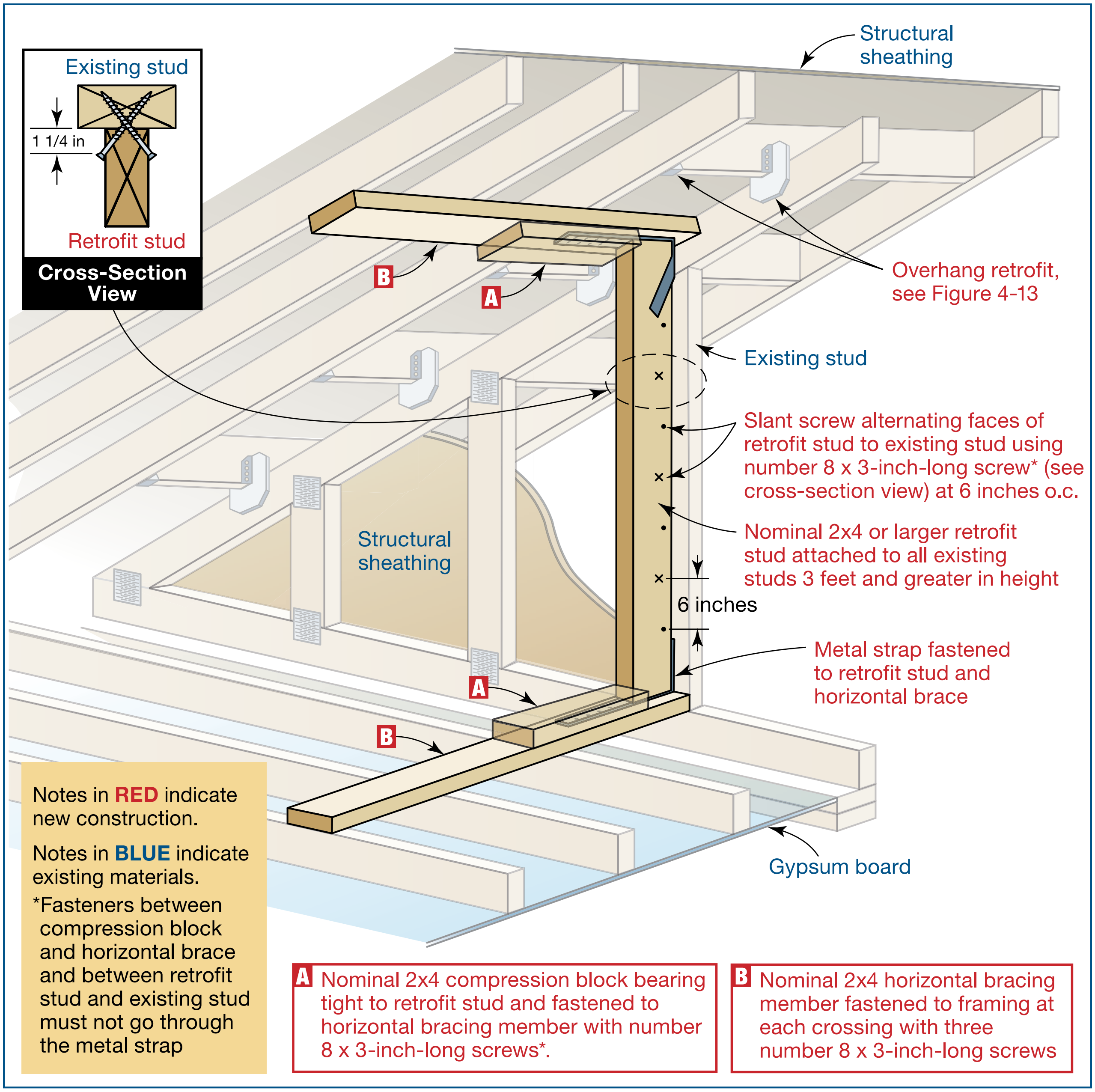


FIGURE 4-16:
Conceptual gable end retrofit with overhangs

At each beam-to-column connection. A connector should be chosen that is appropriate for the location of the connection (e.g., corner beam-to-column connections will require a different connector than inside beam-to-column connections), the required uplift load, and the dimensions of the beam and column. The metal connector should be rated for exterior weather exposure and should be stainless steel if the home is within 3,000 feet of the coast.

At each column-to-foundation connection. A metal column hold-down connector should be used to strengthen the column-to-foundation connection. A moisture barrier should be provided between the connector and concrete foundation. The metal connector should be rated for exterior weather exposure.

If the attached structure is not supported in the configuration described above, it should be evaluated to determine whether it can be retrofitted to resist the required uplift loads using a different prescriptive solution. If no prescriptive solution exists, a professional engineer should be engaged to provide a site-specific retrofit solution. Required loads should be calculated using the wind load criteria in ASCE 7. Some organizations involved in high-wind retrofits have worksheets that can be used to evaluate the required uplift load at each connection. One example of this is the "Uplift Worksheet" in the FORTIFIED *for Existing Homes™ Engineering Guide* (IBHS, 2010), which defines a typical attached structure configuration that matches the criteria described above. The Uplift Worksheet uses a step-by-step method to calculate the required uplift loads for an attached structure using the dimensions of the structure and an uplift pressure table.

4.3 Advanced Mitigation Package

The Advanced Mitigation Package is the most comprehensive package of retrofits in this Guide. This Package can only be effective if the Intermediate Mitigation Package and Basic Mitigation Package (with or without replacing the roof covering) are also implemented as part of the wind retrofit project. The Advanced Mitigation Package requires a more invasive inspection protocol than the previous two packages. Homes that are undergoing substantial renovation or are being rebuilt after a disaster are typically the best candidates for the Advanced Mitigation Package. The Advanced Mitigation Package includes retrofits to provide a continuous load path and protect openings (beyond the requirements of the Intermediate Mitigation Package).

ADVANCED MITIGATION PACKAGE RETROFITS:

- Developing a continuous load path
- Protecting openings from windborne debris and wind pressure

4.3.1 Developing a Continuous Load Path

While structural failures are not as common as other wind-related damage such as damage to the building envelope or wind-driven rain intrusion, such failures have been observed on homes that sustained winds below modern building code requirements. The performance of the home's structural system during a high-wind event depends on whether there is a continuous load path that can transfer loads applied anywhere on the building envelope through the structure and to the foundation. If there is not a continuous load path in the building, the loads may cause a failure related to the missing point of connection. For example, Figure 4-17 shows a house observed by the Hurricane Ike MAT. This home had inadequate connections to transfer loads applied to the roof structure down to the foundation and as a result, the roof structure was destroyed. The wind speeds at this location were estimated to be only 50 mph.

FIGURE 4-17: Roof structure that was poorly connected to the house (Jefferson Parish, LA)
(SOURCE: FEMA P-757)

Implementing a continuous load path through an existing building typically requires the assistance of a professional engineer, although some retrofit programs and guides contain prescriptive solutions to provide continuous load paths through existing residential structures. The FEH program (see Appendix A) is an example of a residential retrofit program that provides prescriptive solutions to develop a load path for homes meeting certain criteria and characteristics. However, due to the large potential variation in structural configuration, construction techniques, and material types, prescriptive solutions for continuous load paths are limited to very simple structures. As a result, most homes will not be eligible for the prescriptive retrofits and will need to engage the services of a professional engineer to develop a retrofit solution specific to the home.

FEMA 499 Technical Fact Sheets No. 4.1 and 4.3 provide guidance on the concept of a continuous load path through the home (Figure 4-18). FEMA 55 provides more detailed guidance and examples of each link through the continuous load path. A solution should be followed that starts at the top of the home (at the roof sheathing), implementing an appropriate fastening schedule and attachment to the roof framing members (see Sections 4.1.3 and 4.1.4 of this Guide), and continuing to the foundation.

The connections between the roof and load-bearing walls should be capable of transferring design loads corresponding to the design wind speed (see Figure 4-19). For homes with both hip and gable roof ends, both types of roof-to-wall connections should be retrofitted, but pay special attention to gable end roof-to-wall connections. Priority should also be given to connecting the corners of the roof to the wall below where the roof members have the greatest span. The retrofits should ensure that the roof truss and rafter retrofitted tie-down is adequate to resist the uplift force and lateral force in two directions at the top of the supporting wall.

Technical Fact Sheet No. 4.3 also discusses wall-to-floor and wall-to-wall connections (see Figure 4-20). These connections continue to transfer loads from the roof system (as well as those picked up by exterior walls) all the way to the foundation and

Note: For information on evaluating shear wall capacity, see Appendix B, Evaluation Guidance.

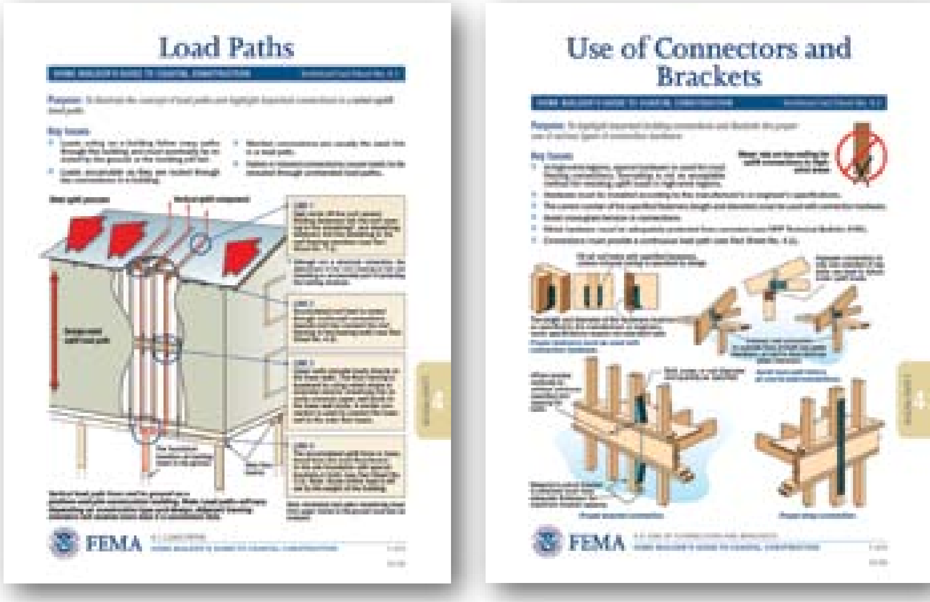


FIGURE 4-18:
FEMA 499 Technical Fact Sheets No. 4.1, *Load Paths* and No. 4.3, *Use of Connectors and Brackets*

into the ground. Figure 4-21 shows foundation connections. The foundation is the last link in a continuous load path. It is critical to ensure that the loads are being transferred to the foundation where large loads must be resisted.

Ensuring Chimneys are Adequately Anchored

If a wood-frame chimney on a home collapses during a high-wind event, significant damage can occur to the home as well as surrounding buildings. Therefore, if a home undergoing a wind retrofit project has a chimney framed with wood, it should be anchored to the structure as part of the continuous load path retrofit so that loads applied to it are transmitted through the load path and adequately resisted. Wood-frame chimneys that are on the interior of the roof and extend 5 feet or less from the roof deck can be retrofitted using prescriptive requirements. The following retrofits should be performed on a qualifying chimney:

1. Tensions straps with a minimum tension capacity of 700 lbs at each end should be fastened to the stud at each corner of the chimney and to the roof framing members below the chimney.

2. Wood structural panels with a minimum nominal thickness of 7/16 inch should be applied to the chimney framing on all sides.

3. Continuous wood blocking supports should be fastened to roof framing members around the base perimeter of the chimney framing using joist hangers. Wood blocking should have minimum dimensions of 2 inches x 4 inches and should be continuous around the chimney framing.

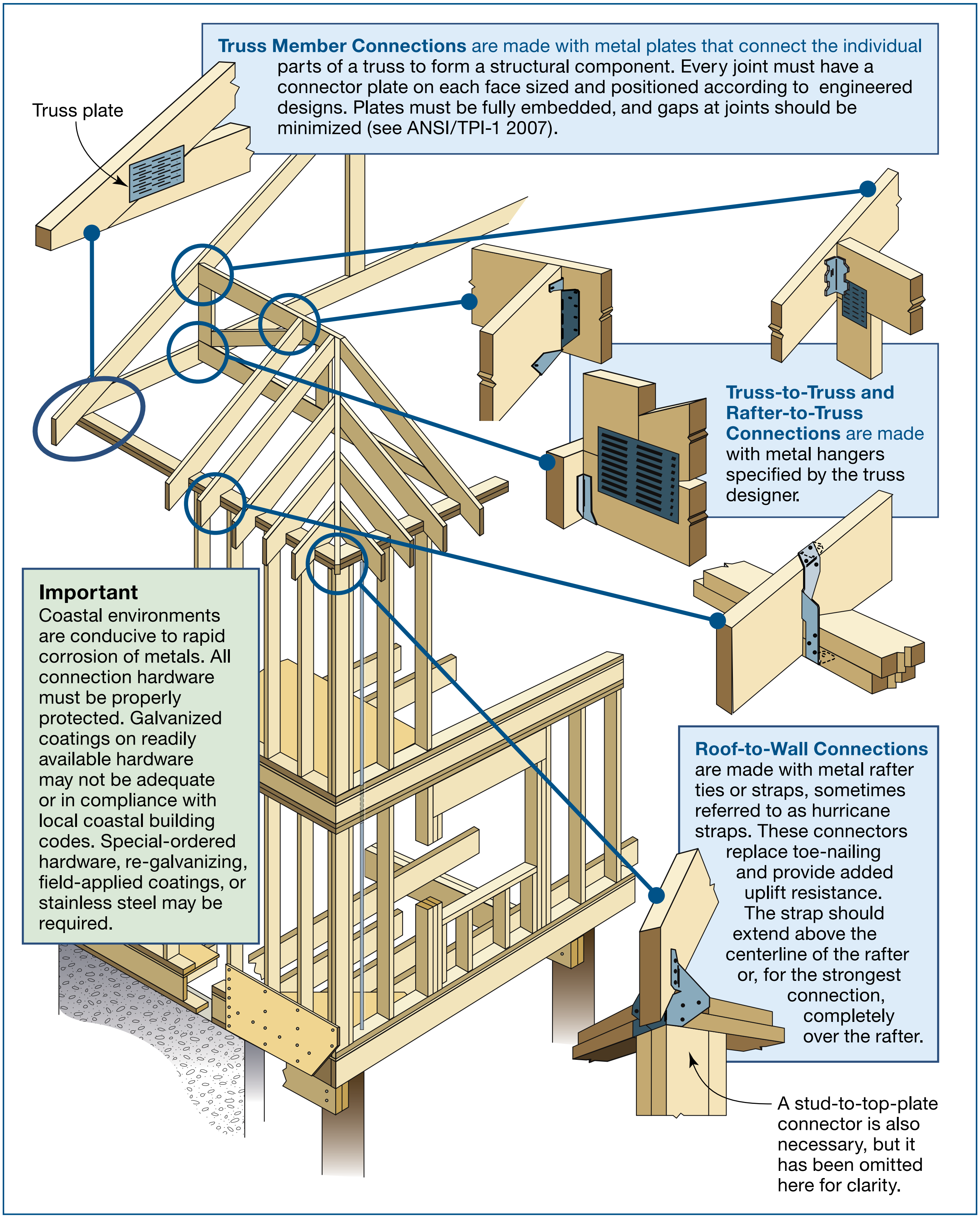


FIGURE 4-19:
Load path connections of a roof system
(SOURCE: FEMA 499)

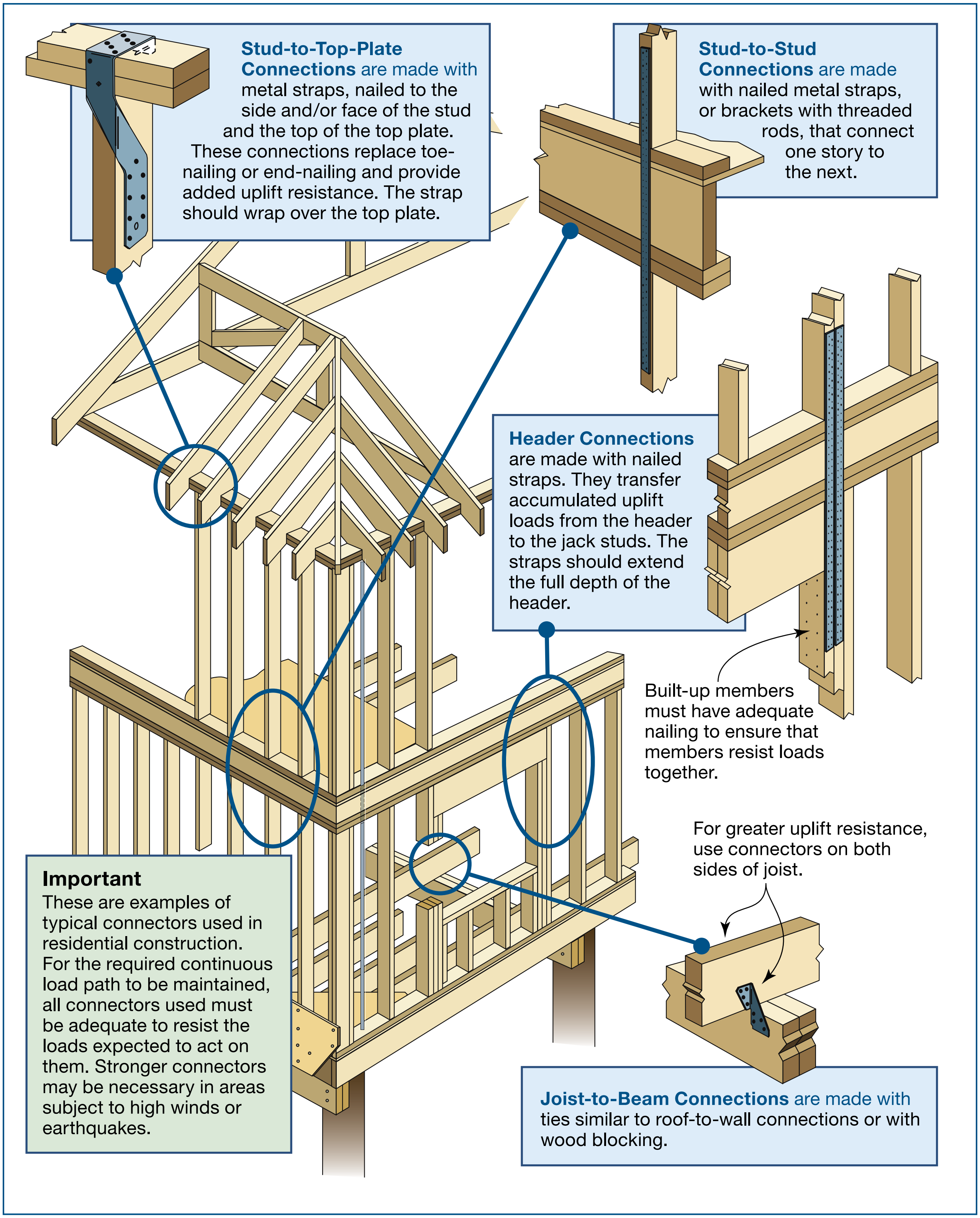


FIGURE 4-20:
Load path connections of a wall system
(SOURCE: FEMA 499)

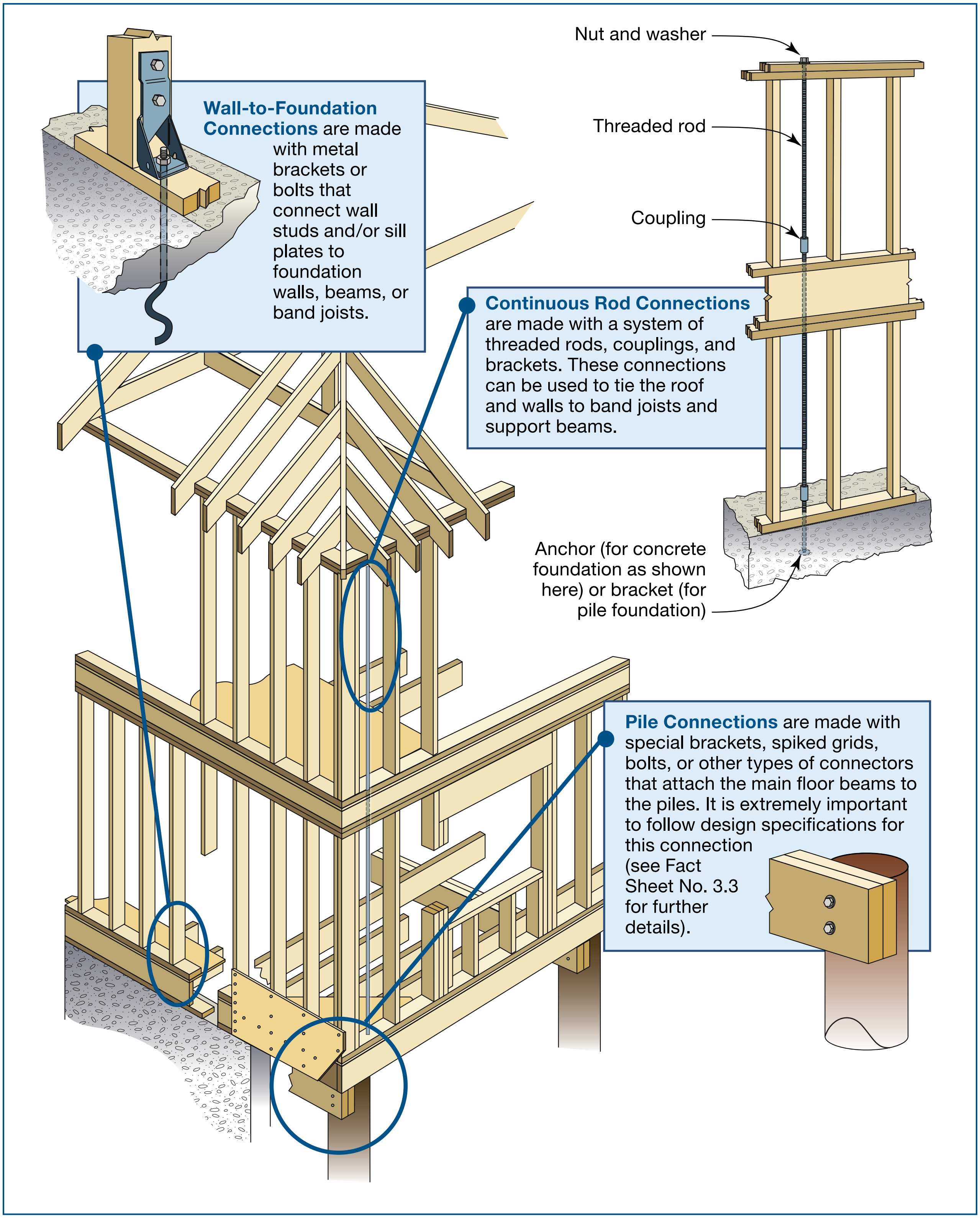


FIGURE 4-21:
Load path connections of a foundation
(SOURCE: FEMA 499)

For more information on this type of solution, consult retrofit programs such as the IBHS FEH program for prescriptive details. If the wood-frame chimney is on the interior of the roof, the entire chimney structure is supported by the roof framing members, which allows the use of the prescriptive solution described above. If the chimney is located along the roof edge, the chimney structure is supported by both roof framing members and a load-bearing wall on the exterior of the building, making a prescriptive retrofit more difficult. Similarly, larger chimneys may require a more detailed and less generic solution to adequately anchor the chimney to the structure. If a chimney exists on the home that extends farther than 5 feet above the roof deck or extends along the roof perimeter, a professional engineer should be engaged to develop a detailed solution. The solution should address the following:

- Chimney wall framing adequacy
- Overturning stability and base shear requirement
- Adequacy and bracing requirements for roof support members
- Attachment schedule of chimney structure to the roof structure

A professional engineer will typically be required to complete the continuous load path retrofit portion of the Advanced Mitigation Package. An engineered solution may involve installing additional metal connectors at the roof level if the side wall framing members are continuous from the bearing wall framing. It may include altering the member size and spacing of roof framing members to support the load from the chimney, installing wood posts at each end of the wall if the chimney side wall framing members start from the top of the supporting wall, or setting posts at the interior side of the wall framing at each corner. A retrofit solution for a masonry chimney will be more difficult than for a wood-frame chimney, and would likely require rebuilding the chimney (at least for the portions above the roof line).

4.3.2 Protecting Openings

The Advanced Mitigation Package provides greater opening protection than the retrofits of the Intermediate Mitigation Package. The Intermediate Mitigation Package opening protection retrofit (see Section 4.2.1) can be completed by installing window and entry door protection that mitigates only windborne debris impacts and not design pressures, and by protecting garage doors from wind pressures and only the glazing the garage doors (if applicable) from windborne debris impacts. In contrast, the Advanced Mitigation Package retrofits address resistance for windows, entry doors, and garage doors (both glazing and door) to both windborne debris impacts and design pressures. The design pressure for an opening is based on factors such as the design wind speed for the project location, exposure category applicable for the surrounding terrain, and the area and location of the opening on the building. Existing opening products that are not rated to resist the design pressures specific to the project location should be removed and replaced with products that do.

Window, skylight, and door products should be tested to demonstrate compliance with ASTM E1233 for the applicable design pressures. Garage doors should be tested to demonstrate compliance with ANSI/DASMA 108 for the applicable design pressures. All windows, skylights, entry doors, and garage doors that should be impact resistant (including opening coverings such as shutter systems) should be tested to demonstrate compliance with ASTM E1996 (using the "D Missile" for the Large Missile Test) in accordance with the procedures defined in ASTM E1886. If a garage door has glazing that is greater than 1 square foot (for one-car garages) or 1.8 square feet (for two-car garages), the glazing should be tested to demonstrate compliance with ANSI/DASMA 115 for impact resistance and cyclical pressure testing. The frame and track of any garage doors should also be checked to ensure the wind load being applied to the strengthened door is transferred into the structural system of the garage.

For windows, entry doors, and garage doors, this retrofit should be done using one of the following two methods:

1. Use window and door assemblies in building openings that are rated to resist design pressures (regardless of whether they are existing products or new products installed as part of the wind retrofit project). Protection from windborne debris impacts must then be provided by impact-resistant coverings that are installed on windows and doors. Coverings should be provided to protect the entire opening and transfer loads to the structural system of the house.

2. Use window and door assemblies in building openings that are rated to resist both design pressures and windborne debris impacts. This configuration, therefore, does not require a covering product to be installed.

The homeowner should work with the contractor, evaluator, and professional engineer (if engineering services are solicited) to determine the most cost-effective method to provide opening protection, as either method may be the most cost-effective choice depending on the scenario. For example, a home could already have a shutter system in place over the windows and doors that is certified to meet the appropriate standards for impact resistance. In such a situation, the most cost-effective retrofit might be to replace any existing windows and doors that are not rated to resist the design pressure with new products that are appropriately rated.

Due to the lack of readily available impact-resistant covering products for skylights, they should be replaced by a product that is certified to resist design wind pressures and windborne debris impacts, rather than be protected by an impact-resistant covering.

4.4 Additional Mitigation Measures

The remainder of this chapter discusses retrofits that mitigate the residual risk of wind-related damages remaining after the Mitigation Packages are implemented. The Mitigation Packages described in this Guide include important retrofits to reduce the risk that a home will experience wind-related damage; however, the risk of damage from a high-wind event cannot be eliminated entirely. By maintaining awareness of the vulnerabilities of and around a home, the risk from wind-related damages can be mitigated even further. While these issues are important to understand, they are not a part of the Mitigation Packages and are not eligible for HMA Program funding.

4.4.1 Exterior Wall Coverings

Exterior wall coverings can be blown off of a building, even during wind events with wind speeds below the design wind speed. Common exterior wall coverings include vinyl siding, brick veneer, fiber-cement siding, and wood and hardboard siding. All types of wall coverings can perform well in high winds if they are properly installed for high winds.

Guidance on the proper installation of vinyl, wood, and fiber cement siding material types is provided in FEMA 499 Technical Fact Sheet No. 5.3 (see Figure 4-22).

FEMA 499 Technical Fact Sheet No. 5.4 (Figure 4-22) provides guidance on the attachment of brick veneer in high-wind regions. Construction guidance such as tie fastener type, spacing, and installation methods are discussed.

FEMA 55 provides guidance on many issues that affect the wall coverings of homes along the coast, as well as guidance on other types of wall coverings not discussed in this Guide.


Sliding Installation in High-Wind Regions

FEMA

Attachment of Brick Veneer in High-Wind Regions

FEMA

FIGURE 4-22:
FEMA 499 Technical Fact Sheets No. 5.3, *Siding Installation in High-Wind Regions* and No. 5.4, *Attachment of Brick Veneer in High-Wind Regions*

4.4.2 Tree Fall

Damage caused by tree fall is commonly observed following high-wind events (see Figure 4-23). Beyond damaging buildings, trees can block roads and driveways, and create a fire hazard. Branches near and over a house should be trimmed and large trees next to a home removed. Homeowners should consult a tree removal professional or botanist to assess the vulnerabilities of any trees on their property. They should consider removing trees that are diseased, have voids in trunks that significantly reduce their ability to withstand wind forces, or are otherwise vulnerable to collapse on nearby structures.

FIGURE 4-23:
A home damaged by fallen trees during Hurricane Katrina (Diamondhead, MS)
(SOURCE: FEMA 549)

4.4.3 Exterior Equipment

Damage may result from exterior equipment that either falls or is torn off a building during a high-wind event. While the Basic Mitigation Package includes retrofits to some rooftop elements such as vents and turbines, not all potential rooftop equipment is covered. Any exterior equipment should be protected from wind-related damage. Unsecured rooftop exterior equipment such as exhaust fans, fan cowlings, and vent hoods can blow off during high-wind events. When this occurs, water can infiltrate the area where they are ripped off of the home; additionally, the equipment can become windborne debris and cause damage to surrounding property. Generally, inadequate anchorage, inadequate strength of the equipment itself, and corrosion of fasteners and straps are the sources of failure of these elements. FEMA 55 provides guidance on mitigating these elements.